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HEATING CUTTING EDGE

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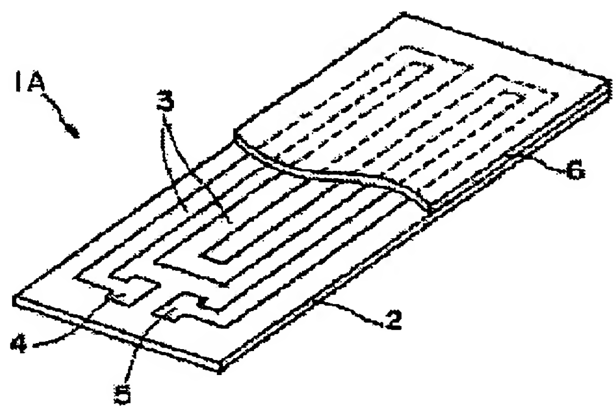
Abstract of **JP8243991**

PURPOSE: To provide a heating cutting edge whose thickness is thin and manufacturing cost is reduced by forming a self-heating type heating cutting edge to melt and cut a resinous tube in such a way that a resistor which is formed in a desired pattern and heats by current-carrying is arranged on a ceramic base board and a surface is covered with an insulating layer.
CONSTITUTION: A heating cutting edge 1A used in a tube connecting device or the like has a ceramic base board 2, and a resistor 3 having a desired pattern where terminals 4 and 5 are arranged in both end parts is formed on this base board 2. An insulating layer 6 composed of an inorganic insulating material such as ceramics and glass is formed on the resistor 3 so as to cover a surface of the resistor 3 except a part of the terminals 4 and 5. Preferably, the resistor 3 is formed by baking this by printing and forming condustive paste in a desired pattern. According to its necessity, a temperature raising fusible part to be fused when a prescribed high temperature condition continues for a prescribed time, is arranged at least in a part of the resistor 3.



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(54) **HOT CUTTING BLADE**

(57) Disclosed is a thermal cutting blade of a self-heating type for melting and cutting a resin tube, comprising a ceramic substrate (2), a resistor element (3) formed on the ceramic substrate in a desired pattern, for generating heat upon power supply, terminal portions (4, 5) formed on both ends of the resistor element, and an insulating layer (6) covering the surface of the resistor element. The thermal cutting blade is excellent in thermal properties, thin due to a simple structure, and is manufactured readily at a low cost.

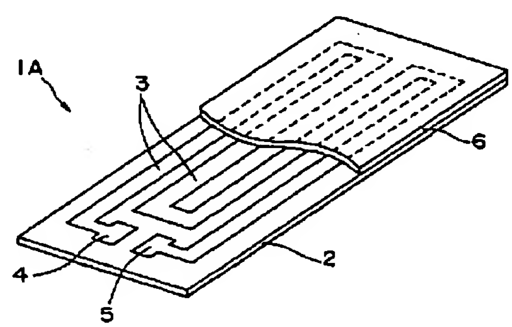

FIG. 1

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Description

[Technical Field]

The present invention relates to a self-heating thermal cutting blade for use in melting and cutting a resin tube.

[Background Art]

To connect flexible resin tubes to each other aseptically, known is a tube connecting apparatus which melts and cuts these tubes and subsequently bonds the cut edges to each other (Jpn. Pat. Appln. KOKOKU Publication No. 61-30582).

The tube connecting apparatus has a pair of holders (block) capable of holding two tubes to be connected, in parallel and a wafer-shaped thermal cutting blade which is movably provided between the two holders in the direction of intersecting these tubes. The manner how to use the device will be described later in detail in connection with embodiments of the present invention. To describe briefly, however, the manner is as follows:

First, the wafer-shaped thermal cutting blade is heated, while reversely-directed two tubes are being held by the two holders in parallel. The tubes are melted and cut by moving the heated thermal cutting blade. Then, one of two holders is moved in such a direction perpendicular to the longitudinal direction of the tubes to coincide the cut edges of the tubes to be bonded to each other. When the cutting blade is removed from this state, the molten cutting edges of two tubes are brought into direct contact with each other, thereby attaining fusion bonding.

The wafer-shaped cutting blade to be used in the conventional tube connecting device mentioned above has a structure which comprises a metal plate folded in half and a resistor element formed in a desired pattern on the inner surface of the metal plate via an insulating layer (adhesion layer). When power is supplied to the resistor element by way of the terminals formed on the both ends, the resistor element generates heat, raising temperature of the entire wafer (Jpn. Pat. Appln. KOKAI Publication No. 59-49925).

However, the conventional wafer-shaped cutting blade has a complicated five-layered structure consisting of a metal plate, insulating layer, resistor element, insulating layer, and metal plate, with the result that the wafer is inevitably thick. The thick blade is disadvantageous when a tube is melted, cut and fuse-bonded, decreasing the yield of successfully connected tubes.

Furthermore, in manufacturing the wafer, many steps are required such as an insulating layer forming step, a resistor element forming step, a metal plate folding step, thereby increasing a manufacturing cost and a material cost.

[Disclosure of the Invention]

An object of the present invention is to improve a thermal cutting blade for use in such a tube connecting device as mentioned above, and more specifically, to provide a thermal cutting blade which has a reduced thickness due to a simple structure and can be manufactured at a low cost.

The object can be attained by a thermal cutting blade of a self-heating type for melting and cutting a resin tube, comprising a ceramic substrate; a resistor element formed on the ceramic substrate in a desired pattern, for generating heat upon power supply; terminal portions formed on both ends of the resistor element; and an insulating layer covering the surface of the resistor element.

Furthermore, the aforementioned object can be achieved by a thermal cutting blade of a self-heating type for melting and cutting a resin tube, comprising a metal substrate; a first insulating layer made of an inorganic insulating material and formed on the metal substrate; a resistor element formed on the first insulating layer in a desired pattern; terminal portions formed on both ends of the resistor element; and a second insulating layer covering the surface of the resistor element.

In an embodiment of the present invention, the insulating layer (at least the first insulating layer when first and second insulating layers are employed) is formed of an inorganic insulating material.

In another embodiment of the present invention, said resistor element is formed by printing the conduvtive paste in a desired pattern and baking it. It is possible to form the resistor element and the insulating layer (at least the first insulating layer when first and second insulating layers are employed) by simultaneous baking. Particularly in this case, the first insulating layer, the resistor element and the second insulating layer may be formed by simultaneous baking.

In a further embodiment, a fuse portion susceptible to fuse or melt-off when a predetermined high temperature is maintained for a predetermined time period, are provided in at least one part of the resistor element.

[Brief Description of the Drawings]

FIG. 1 is a perspective view showing an embodiment of the thermal cutting blade of the present invention;

FIG. 2 is a perspective view showing another embodiment of the thermal cutting blade of the present invention;

FIG. 3 is a further embodiment of the thermal cutting blade of the present invention;

FIG. 4 is a perspective view showing a structure of a tube connecting apparatus for cutting and connecting tubes by use of the thermal cutting blade of the present invention; and

FIGS. 5 to 8 are perspective views showing connecting steps of tubes by use of the tube connect-

ing apparatus shown in FIG. 4.

[Best Mode of Carrying Out the Invention]

Hereinbelow, the thermal cutting blade of the present invention will be described based on preferable embodiments shown in the accompanying drawings.

FIG. 1 is a perspective view showing an embodiment of the thermal cutting blade of the present invention. A thermal cutting blade 1A of the present invention has a ceramic substrate 2, as shown in the figure. The ceramic material constituting the ceramic substrate 2 may be either an oxide series ceramic material or a nonoxide series ceramic material. For example, alumina (Al_2O_3), silica (SiO_2), beryllia (BeO), silicon carbide (SiC), aluminum nitride (AlN), boron nitride (BN), and silicon nitride (Si_3N_4) may be used either singly or in combination of at least two of these compounds (for example, SIALON). In addition, at least one compound selected from SiO_2, B_2O_3, PbO, ZnO_2, MgO, CaO, BaO, SrO, and Y_2O_3 may be added.

The ceramic substrate 2 further acts as an insulating layer for a resistor element 3 described later since it has not only sufficient rigidity but also insulating properties inherent thereto.

The ceramic substrate 2 is not particularly restricted in thickness as far as it has a sufficient strength resistible to the cutting of a tube.

On the ceramic substrate 2, the resistor element 3 is formed in a desired pattern. Onto the both ends of the resistor element 3, terminals 4 and 5 are formed. The materials of the terminals 4 and 5 may be the same as that of resistor element 3. It is preferable that the resistor element 3 and the terminals 4 and 5 (hereinafter collectively referred to as "resistor element 3 etc.") be simultaneously formed by using a screen printing, decalcomania process, etching, plating, vapor deposition, sputtering, CVD or the like.

Examples of a metal material constituting the resistor element 3 include Ag; Ag series alloys such as Ag-Pd alloy, Ag-Pt alloy and Ag-Pd-Pt alloy; Au; Au series alloys such as Au-Cu alloy; Ni; Ni series alloys such as Ni-Cr alloy; Fe series alloys such as stainless steel; Cu; Cu series alloys such as Cu-Zn alloy and Cu-Sn alloy; Al; and Al series alloys such as Al-Mg alloy and Al-Cu alloy. In the case where the resistor element 3 is formed by printing, it is preferred to use the so-called thick-film conductive paste or thick-film resistor paste having Ag particles or Ag series alloy particles connected to each other by a glass binder.

The thickness (cured state) of the resistor element 3 etc., which is not particularly restricted, is preferably from about 10-25 μm, and more preferably about 10-15 μm.

The resistivity of the resistor element 3 is preferably about 5-50 Ω, and more preferably about 5-20Ω.

On the resistor element 3, an insulating layer 6 is formed so as to cover the surface of the resistor element 3 except for the terminals 4 and 5. The insulating layer 6 is formed of a coating film made of any one of various ceramic materials as mentioned above; an inorganic material such as a glass including borosilicate glass, lead glass, phosphate glass; or an organic material having heat resistance, such as polyimide. In particular, the insulating material 6 is preferably formed of a ganic insulating material such as the ceramic material mentioned above or glass. Incidentally, as the ceramic material, the same ceramic material as those mentioned with respect to the ceramic substrate 2 may be used.

The thickness (cured state) of the insulating layer 6, which is not particularly restricted, is preferably about 1-100 μm, and more preferably about 5-50 μm.

The thickness of the thermal cutting blade 1A, which is not particularly restricted, is preferably about 0.1-2.5 mm, more preferably about 0.1-1.3 mm, and most preferably about 0.2-0.5 mm. If the thickness of the thermal cutting blade 1A is excessively thin, fractures such as cracks and cutouts, will be readily produced. Consequently, it will be difficult to handle the blade 1A. Conversely, if the thermal cutting blade 1A is excessively thick, it will be difficult to connect tubes after they are cut by melting. In addition, the bonding strength decreases.

It is useful to reduce the thickness of the thermal cutting blade 1A for cutting and connecting tubes. In addition, the following advantages are accompanied. That is, in the case where a plurality of thermal cutting blades 1A are superimposed and housed in a cartridge (case) not shown herein, the number of thermal cutting blades 1A housed in the cartridge of a constant volume, can be increased.

The thermal cutting blade 1A mentioned above has excellent thermal conductivity and heat resistance since the surface is formed of a ceramic material. Therefore, very stable heat properties can be ensured.

Hereinbelow, the method of manufacturing the thermal cutting blade 1A will be described by way of example with reference to the case where the resistor element 3 and the insulating layer 6 are formed by simultaneous baking after the resistor element 3 etc. are formed by coating a conductive paste by use of the screen printing.

[1A] On the ceramic substrate 2 (large and uncut base plate) manufactured in advance, a conductive paste for forming the resistor element 3 etc. is coated in a predetermined pattern by use of the screen printing.

As a conductive material, a main ingredient of the conductive paste, various metals or metal compounds are usually used in the form of particles. Among these, Ag or an Ag series alloy is particularly preferable. As the Ag series alloy, use may be made of Ag-Pd alloy, Ag-Pt alloy, Ag-Pd-Pt alloy, and the like. The Ag-series alloy containing Pd is superior in migration resistance, compared to pure Ag. Such Ag or an Ag series alloy is usually present in the form of particles in the conductive paste. The

average diameter of particles of Ag or the Ag series alloy is preferably about 0.5-50 μm, and particularly, about 1-20 μm. If the average diameter is less than 0.5 μm, a shrinkage rate of the resistor element 3 etc. will increase. Conversely, in the excess of 50 μm, printing properties and dispersing properties of the conductive paste will decrease in some cases.

As the conductive material, instead of or in addition to Ag or the Ag series alloy, Cu, Au or an alloy containing Cu and Au may be used. Alternatively, the conductive material may include ruthenium dioxide or a conductive double oxide complex such as lead ruthenate.

As a vehicle for the conductive paste, use may be made of binders such as epoxy resin, thermoset melamine resin, acryl series resin, nitrocellulose, ethylcellulose, phenol resin, vinyl resin, and polyimide resin; solvents such as alcohols, toluene, xylene, butyl carbitol, and terpineol; thermoset resins such as polyvinyl chloride for improving plasticizing action; other agents such as dispersant, activating agent, viscosity modifier, film adhesiveness accelerating substance (for example, metal oxide), resistance modifying substance. These agents can be arbitrarily and appropriately blended depending on purposes.

In particular, in the case where the screen printing is carried out by using such a conductive paste mentioned above, it is preferred to use a screen having 180 - 300 meshes, particularly, 200-250 meshes.

The film thickness of the resistor element 3 etc. can be readily set by appropriately controlling conditions for the screen printing, such as the thickness of a screen emulsion coating, rubber hardness of a squeegee, the distance between a screen and a substrate to be printed, and a moving rate of the squeegee.

In the present invention, the conductive pastes for use in the resistor element 3, terminals 4 and 5 may differ in conditions such as composition, viscosity, and film thickness.

[2A] To a raw material, such as an alumina powder, of the insulating layer 6, a binder and a solvent are added. The resultant mixture is kneaded to obtain a slurry. The average diameter of the alumina powder to be used is preferably about 0.1-100 μm, and more preferably, about 0.1-10 μm.

Subsequently, after the terminals 4 and 5 are masked, if necessary, in a desired form (e.g., a disk form), the aforementioned slurry is coated on the entire surface of the substrate 2 and the resistor element 3, and then dried. As the coating method, there are screen printing, spray, dipping, roll coating, and the like.

A method for forming the insulating layer 6 is not restricted to the coating methods mentioned above. The insulating layer may be formed by, for example, preparing a green sheet of a base material for the insulating layer by a doctor blade method, and then, laminating the green sheet on the substrate and the resistor element.

[3A] The conductive paste of the resistor element 3 and the coating film of the insulating layer 6, formed on the ceramic substrate 2, are baked simultaneously at a low temperature by using a furnace, for example. The baking is preferably performed at a temperature of 200-950°C, and more preferably at a temperature of 500-950°C, for 5-30 minutes.

Note that, if necessary before baking, thermal press and binder removing treatment may be applied. Cutting grooves may be formed.

[4A] The large size base plate thus manufactured is cut into pieces of a predetermined size. In this manner, a plurality of thermal cutting blades 1A are obtained.

Hereinbelow, we will explain the method of manufacturing the thermal cutting blade 1A in connection with the case where the conductive paste, a material for the resistor element and a ceramic material for forming the insulating layer 6 are coated by the screen printing process in the order mentioned.

[1A] On the ceramic substrate 2 (large and uncut base plate) manufactured in advance, a conductive paste for forming the resistor element 3 etc. is coated in a predetermined pattern by use of the screen printing.

As the conductive material, a main ingredient of the conductive paste, various metals or metal compounds are usually used in the form of particles. Among these, Ag or an Ag series alloy is particularly preferable. As the Ag series alloy, use may be made of Ag-Pd alloy, Ag-Pt alloy, Ag-Pd-Pt alloy, and the like. The Ag-series alloy containing Pd is superior in migration resistance, compared to pure Ag. Such Ag or an Ag series alloy is usually present in the form of particles in the conductive paste. The average diameter of particles of Ag or the Ag series alloy is preferably about 0.5-50 μm, and particularly, about 1-20 μm. If the average diameter is less than 0.5 μm, a shrinkage rate of the resistor element 3 etc. will increase. Conversely, in the excess of 50 μm, printing properties and dispersing properties of the conductive paste will decrease in some cases.

As the conductive material, instead of or in addition to Ag or the Ag series alloy, Cu, Au or an alloy containing Cu and Au may be used. Alternatively, the conductive material may include ruthenium dioxide or a conductive double oxide complex such as lead ruthenate.

As a vehicle for the conductive paste, use may be made of binders such as epoxy resin, thermoset melamine resin, acryl series resin, nitrocellulose, ethylcellulose, phenol resin, vinyl resin, and polyimide resin; solvents such as alcohols, toluene, xylene, butyl carbitol, and terpineol; thermoset res-

ins such as polyvinyl chloride for improving plasticizing action; other agents such as dispersant, activating agent, viscosity modifier, film adhesiveness accelerating substance (for example, metal oxide), resistance modifying substance. These agents can be arbitrarily and appropriately blended depending on purposes.

In particular, in the case where the screen printing is carried out by using such a conductive paste mentioned above, it is preferred to use a screen having 180 - 300 meshes, particularly, 200-250 meshes.

The film thickness of the resistor element 3 etc. can be readily set by appropriately controlling conditions for the screen printing, such as the thickness of a screen emulsion coating, rubber hardness of a squeegee, the distance between a screen and a substrate to be printed, and a moving rate of the squeegee.

In the present invention, the conductive pastes for use in the resistor element 3, terminals 4 and 5 may differ in conditions such as composition, viscosity, and film thickness.

The conductive paste of the resistor element 3 formed on the ceramic substrate 2 by the screen method, is baked at a low temperature by using a furnace, for example. The baking is preferably performed at a temperature of 200-950°C, and more preferably at a temperature of 500-950°C, for 5-30 minutes.

[2A'] To a raw material, such as an alumina powder, of the insulating layer 6, a binder, and a solvent are added. The resultant mixture is kneaded to obtain a slurry. The average diameter of the alumina powder to be used is preferably about 0.1-100 μm, and more preferably, about 0.1-10 μm.

Subsequently, after the terminals 4 and 5 are masked, if necessary, in a desired form (e.g., a disk form), the aforementioned slurry is coated on the resistor element 3, and then dried. As the coating method, there are screen printing, spray, dipping, roll coating, and the like.

A method for forming the insulating layer 6 is not restricted to the coating methods mentioned above. The insulating layer may be formed by, for example, preparing a green sheet of a base material for the insulating layer by a doctor blade method, and then laminating the green sheet on the resistor element 3.

The coating film of the insulating layer 6 formed on the resistor element 3, is baked at a low temperature by using a furnace, for example. The baking is preferably performed at a temperature of 200-950°C, and more preferably at a temperature of 500-950°C, for 5-30 minutes.

[3A'] In the meantime, if necessary before baking, thermal press and binder removing treatment may be applied. Cutting grooves may be formed.

[4A'] The large size base plate thus manufactured is cut into pieces of a predetermined size. In this manner, a plurality of thermal cutting blades 1A are obtained.

The resistor element 3 etc., can be manufactured easily in a short time by the aforementioned screen printing method, even if the resistor element 3 etc. have a complicated and fine pattern. As a result, the manufacturing cost can be reduced. Furthermore, since the pattern of resistor element 3 is improved in dimensional accuracy, a reproducible resistivity with high accuracy can be obtained. To be more specific, the error of the resistivity of the resistor element 3 compared to a designed resistivity can be within ±5%, in particular, within ±1.5%.

Since the resistor element 3 etc. exhibit a high adhesivity to the ceramic substrate 2, the peeling-off of the resistor element 3 does not take place during the manufacturing steps.

In the case where the conductive paste of the resistor element 3 and the coating film of the insulating layer 6 are simultaneously baked, the manufacturing is performed in simple steps, reducing the manufacturing cost.

It should be noted that, instead of the ready-made ceramic substrate 2 (baked in advance), use may be made of, for example, an unbaked green sheet which is prepared by the doctor blade method and have not yet been baked. In this case, the resistor element pattern made of the conductive paste and an insulating film coating layer may be formed in the order mentioned on the greet sheet, and then the entire construct thus obtained may be baked simultaneously. Alternatively, individual layers may be baked separately.

The formation method of the resistor element 3 of the present invention, which is not restricted to the screen printing method, may include a method in which a metal foil such as stainless steel foil or nickel chrome foil is punched in a desired pattern. Alternatively, the resistor element 3 is formed in a desired pattern by etching a conductive thin film formed by plating, deposition, sputtering CVD, or the like.

FIG. 2 is a perspective view showing another embodiment of the thermal cutting blade of the present invention. As shown in the figure, a thermal cutting blade 1B has a metal substrate 21. The metal substrate 21 is formed of a metal having an excellent thermal conductivity which permits heat to diffuse and distribute uniformly along the substrate surface. Specific examples of the metal include copper, aluminium, gold, silver, iron, nickel, cobalt, titanium, and an alloy containing any one of the metals mentioned (e.g., stainless steel, brass, copper-beryllium alloy, aluminium alloy, and titanium alloy). Of these metals, copper or a copper alloy (especially containing copper in an amount of 99.9 wt% or more) is preferable.

The preferable thickness of the metal substrate 21, which varies with the constituting materials, is preferably about 0.05-2.5 mm, and more preferably, 0.1-0.5

mm.

To increase the adhesive strength of a first insulating layer 22, the surface of the metal substrate 21, on which the first insulating layer 22 is formed, may be rendered rough. To make a rough surface, the surface of the metal substrate 21 may be treated by a rough surface processing such as rolling by a rough surface roll, sand blasting, or jet scribing.

On the metal substrate 21, the first insulating layer 22 is formed. The first insulating layer 22 is preferred to have the same constitution as that of the insulating layer 6 of the embodiment shown in FIG. 1. More specifically, the first insulating layer 22 is preferably formed of any one of various inorganic insulating materials.

The thickness of the first insulating layer 22 (cured state), which is not particularly restricted, is preferably 3 to 100 μm, and more preferably 5-50 μm.

On the first insulating layer 22, the resistor element 3 and terminals 4 and 5 are formed in the same manner as described in the embodiment of FIG. 1.

On the resistor element 3, a second insulating layer 61 corresponding to the insulating layer 6 of the embodiment of FIG. 1, is formed so as to cover the surface of the resistor element 3 except for the terminals 4 and 5.

The same advantages as mentioned in the embodiment of FIG. 1 can be obtained with respect to the thermal cutting blade 1B of the embodiment of FIG. 2. In addition, in the thermal cutting blade 1B of this embodiment, since the metal substrate 21 has a quite high strength, the occurrence of fractions such as splits, cutouts, and cracks are successfully prevented. Consequently, the thermal cutting blade 1B can be reduced in thickness.

Hereinbelow, the method of manufacturing the thermal cutting blade 1B will be described by way of example with reference to the case where the resistor element 3 etc. are formed by the screen printing process, and where the first insulating layer 22, the resistor element 3, and the second insulating layer 61 are formed by simultaneous baking.

[1B] On the metal substrate 21 (large and uncut base plate) manufactured in advance, the first insulating layer 22 is formed. To be more specific, to a raw material, such as an alumina powder, of the first insulating layer 22, a binder and a solvent are added. The resultant mixture is kneaded to obtain a slurry. Thereafter, the slurry is coated on the surface of the metal substrate 21 and dried.
[2B] The conductive paste for forming resistor element 3 etc. is coated in a predetermined pattern by the screen printing method in the same manner as in step [1A] of the previous embodiment.
[3B] The second insulating layer 61 is coated on the resistor element 3 in the same manner as in step [2A] of the previous embodiment.
[4B] The coating film of the first insulating layer 22 formed on the metal substrate 21, the conductive paste of the resistor element 3, and the second coating insulating layer 61, are baked simultaneously at a low temperature by using a furnace, for example. The suitable baking conditions and the pretreatment for the baking are the same in step [3A] of the previous embodiment.
[5B] The base plate thus manufactured is cut (divided) into pieces of a predetermined form. In this manner, a plurality of thermal cutting blades 1B are obtained.

Note that, in order to form the first insulating layer 22 and the second insulating layer 61, a green sheet may be used in the same manner as in the previous embodiment. Furthermore, only the coating film for the first insulating layer 22 and the conductive paste for resistor element 3, may be baked simultaneously.

Hereinbelow, the method of manufacturing the thermal cutting blade 1B will be described by way of example with reference to the case where the first insulating layer 22, the resistor element 3, and the second insulating layer 61 are baked in the order mentioned.

[1B'] On the metal substrate 21 (large and uncut base plate), the coating film for the first insulating layer 22 is formed. To be more specific, to a raw material, such as an alumina powder, of the first insulating layer 22, a binder and a solvent are added. The resultant mixture is kneaded to obtain a slurry. Thereafter, the slurry is coated on the surface of the metal substrate 21 and baked at a low temperature. The low temperature baking is, for example, preferably performed by using a furnace, preferably at a temperature of 200-950°C, and more preferably at a temperature of 500-950°C, for 5-30 minutes, as described in the previous embodiment.
[2B'] The conductive paste for forming the resistor element 3 etc. is coated in a predetermined pattern by the screen printing method, in the same manner as in step [1A'] of the previous embodiment. Subsequently, the low temperature baking is performed in the same manner as in step [1A'].
[3B'] The coating film for the second insulating layer 61 is formed on the resistor element 3 in the same manner as in step [2A'] of the previous embodiment. Subsequently, the low temperature baking is performed in the same manner as in step [2A'].
[4B'] The base plate thus manufactured is cut (divided) into pieces of a predetermined form. In this manner, a plurality of thermal cutting blades 1B are obtained.

FIG. 3 is a perspective view showing a further embodiment of the thermal cutting blade of the present invention. A thermal cutting blade 1C shown in the figure is the same as the thermal cutting blade 1A except that a high temperature fuse portion 31 is provided in a part of the resistor element 3.

The high temperature fuse portion 31 is formed of a

material which is readily melt and cut if a predetermined high-temperature state is maintained for a predetermined time. By way of example, these are low-melting point alloys represented by a tin-lead alloy.

The temperature at which the high temperature fuse portion 31 is melt and cut, is lower than the melting temperature of a tube, for example, about 320°C. The time period required for cutting the high temperature fuse portion 31 at the temperature mentioned above is equal to or shorter than the time required for the cutting and connecting of the tubes, for example, about 10 minutes.

The thermal cutting blade of the present invention is basically disposable (single use). In the case of the thermal cutting blade 1C, it is easily to know whether the blade is an unused one or a used one based on the fact that current flows or does not flow between the terminals 4 and 5. More specifically, upon power supply to the resistor element 3 via the terminals 4 and 5, when used, the resistor element 3 generates heat, raising temperature of the blade over the fusing temperature or more. Consequently, the high temperature fuse portion 31 is melt and cut when the fusing temperature is maintained during the predetermined time period. As a result, even if power is supplied between the terminals 4 and 5, next time, the resistor element 3 will not generate heat. It is therefore evident that the thermal cutting blade 1C has been used once. In this way, the blade can be prevented from being used for a plurality of times, beforehand.

In the thermal cutting blade 1C of this embodiment, the fuse portion 31a is provided in a part of the resistor element 3. Instead, the entire resistor element 3 may be formed of a material capable of being melted and cut if the predetermined high temperature state is maintained for a predetermined time period. In this case, the fuse portion 31 resides in the center portion of the resistor element 3, which is the portion highest in temperature when power is supplied via the terminals 4 and 5. The center portion is melt and cut when once used, and therefore, the repeat usage of the blade can be prevented, beforehand.

The fuse portion 3 may be included by a bypass (not shown) circuit which goes round the entire portion or a part of the resistor element 3. In this case, when the thermal cutting blade is used for the first time, current flows through the fuse portion by going round the entire or a part of the resistor element 3, upon power supply to the thermal cutting blade via the terminals 4 and 5. As a result, the fuse portion generates heat and fuses. Thereafter, current flows the entire portion of the resistor element 3, which then generates heat. In contrast, in the case of second usage onwards, since the fuse portion has been already melted and cut, current flows the resistor element 3 in its entirety, immediately upon power supply via terminals 4 and 5, resulting heat generation from the resistor element. Hence, by detecting the voltage increase patterns between the terminals 4 and 5, it is possible to know whether the thermal cutting blade is unused or used.

The thermal cutting blade 1C mentioned above can be manufactured in the same manner as in the manufacturing steps [1A]-[4A] of the thermal cutting blade 1A, shown in FIG. 1. In this case, the conductive paste for the resistor element 3 and the conductive paste for the fuse portion 31 may be formed in desired patterns separately by different screen printing processes in step [1A]. In addition, the fuse portion 31 may be formed after the resistor element 3 is baked.

Such a fuse portion as mentioned above may be provided also in the thermal cutting blade 1B described in the embodiment of FIG. 2. In this case, the similar advantages can be also obtained.

Hereinbelow, we will explain an example of a tube connecting method using any one of the thermal cutting blades 1A-1C of the present invention. One of the thermal cutting blades 1A to 1C (hereinafter, representatively referred to as "thermal cutting blade 1A") is used by being installed in a predetermined tube connecting apparatus.

FIG. 4 is a perspective view showing a structure of a tube connecting apparatus 40, and FIGS. 5 to 8 are perspective views, each showing a connecting step of tubes 14 and 15 by use of the tube connecting apparatus 40. As shown in these figures, the tube connecting apparatus 40 has a structure comprising a pair of holders 41 and 42 and the thermal cutting blade 1A of the present invention which is replaceably provided between the holders. When the apparatus is used, two polyvinyl chloride tubes 14 and 15 are placed adjacent to each other between holders 41 and 42. The tubes are then melted and cut by the thermal cutting blade 1A which has been heated. Subsequently, the holder 41 is moved to coincide cut edges of the tubes to be connected to each other. After the thermal cutting blade 1A is removed, tubes 14 and 15 are fuse-bonded each other.

To describe more precisely, the holder 41 shown in FIG. 4 is divided into a holder piece 411 and a holder piece 412 which corresponds to an upper piece and a lower piece, respectively. Similarly, the holder 42 is also divided into a holder piece 421 and a holder piece 422. These holder pieces 411, 412, 421 and 422 are individually rotatable around a supporting point 44.

In the inner surfaces of the holders 411 and 412, which face to each other, two grooves 45 and 46 having sectional shapes of a half-disk, are formed in parallel. Further, in the inner surfaces of the holders 421 and 422, the two grooves 45 and 46 are provided in the same manner. When the holder piece 411 is superimposed on the holder piece 412, and the holder piece 421 on the holder piece 422, tube holding portions 47 and 48 are formed having a sectional shape of a disk-form.

Although not shown in the figures, to the end portions of the holders 41 and 42, near the thermal cutting blade 1A, tube sandwiching portions may be provided which sandwich the tubes 14 and 15 when holder

pieces 411 and 412, and 421 and 422 are closed. In the sandwiching portions, the tubes are made flat and the interior portions are blocked.

Hereinbelow, we will explain the tube connecting method by using a tube connecting apparatus 40.

As shown in FIG. 5, the tubes 14 and 15 are placed in the grooves 45 and 46 of the holders 41 and 42 in such a manner that blocked end portions 16 and 17 are directed in the reverse directions to each other. Then, the two tubes 14 and 15 are sandwiched and fixed in the tube holding portions 47 and 48 by closing the holder pieces 411 and 412, and 421 and 422.

On the other hand, one piece of the thermal cutting blade 1A is taken out from the cartridge and set at a thermal cutting blade supporting portion (not shown) present in the lower space between holders 41 and 42.

Subsequently, power, e.g., a voltage of 15-24V, is supplied by power supplying means (not shown) to the resistor element 3 in the thermal cutting blade 1A via terminals 4 and 5 of the thermal cutting blade 1A. Consequently, the resistor element 3 generates heat. The thermal cutting blade 1A is heated to a temperature (for example, 260-330°C) of a melting point of the tubes 14 and 15, or more.

When the thermal cutting blade 1A is moved toward the upper side in the figure from this state, as shown in FIG. 6, the tubes 14 and 15 are melt and cut with heat of the thermal cutting blade 1A. At this point, the cut edges of the tubes 14 and 15 maintain a molten and soften state of high-temperature. Since the cut edges are not communicated with the outside, an aseptic condition within the tubes can be maintained.

Then, as shown in FIG. 7, the holder 41 is moved in the direction perpendicular to the longitudinal direction of the tube, within the plane of the tube arrangement, while the tubes 14 and 15 maintain the molten state. When the cut edges of the tubes 14 and 15 are coincided to each other, the movement of the holder 41 is terminated and immobilized.

As shown in FIG. 8, after the thermal cutting blade 1A is moved toward the lower side in the figure, the holder 42 is moved by a small distance in the longitudinal direction of the tubes 14 and 15 so as to come closer to the other holder 41. In this manner, the molten cut edges of the tubes 14 and 15 are contacted and connected to each other, accomplishing the connection of the tubes 14 and 15.

During the throughout operations beginning from the step of cutting two tubes 14 and 15 by the thermal cutting blade 1A to the step of connecting the cut edges, the cut edges of the tubes 14 and 15 and their peripheral portions maintain a molten and soften state at a high-temperature. Furthermore, until the cut edges are adhered and connected, individual cut edges are in tight contact with the surfaces of the thermal cut blade 1A, preventing the communication with the outside. Therefore, during the throughout operations, the aseptic state of the interior of the tubes can be maintained almost completely.

After the tubes 14 and 15 are connected as mentioned above, tube pieces 141 and 151 having the blocked ends 16 and 17 of the tubes are discarded.

When other tubes are connected next time, the used thermal cutting blade 1A is substituted with a new one and the used thermal cutting blade 1A is discarded. In the case of thermal cutting blade 1C, it is possible to know whether the thermal cutting blade is a used one or an unused one. The possibility can be avoided in which an unused thermal cutting blade 1C is inadvertently used.

In the foregoing, the thermal cutting blade is described based on embodiments shown in figures. However, the present invention will not be limited to the specific embodiments.

As is explained in the foregoing, since an inorganic insulating material is used either for the substrate itself or for the surface on which a resistor element is formed, the thermal cutting blade of the present invention is excellent in thermal conductivity and heat resistance and has a large heat capacity. In addition, since the structure of the thermal cutting blade is simple and the number of the layers constituting the blade is small, the thickness of the thermal cutting blade can be reduced. Therefore, melting, cutting, and fusion bonding of tubes can be carried out quite satisfactorily. As a result, the connected portions are excellent in bonding strength and air tightness as well as in an ascetical state. In addition, in the particular case where a ceramic substrate is used, a material cost can be reduced. In the case where a metal substrate is used, the thickness of the thermal cutting blade can be reduced.

The thermal cutting blade of the present invention can be readily manufactured. In particular, in the case where a resistor element and an insulating layer are formed by printing a conductive paste in a desired pattern and simultaneously baked, it is possible to reduce the manufacturing steps. Hence, the productivity is improved and cost can be significantly reduced.

Furthermore, in the case where a high-temperature fuse portion is provided in at least one portion of the resistor element, it is possible to know whether the thermal cutting blade is a used one or an unused one. Hence, the reuse of the thermal cutting blade can be prevented beforehand.

Claims

1. A thermal cutting blade of a self-heating type for melting and cutting a resin tube, comprising

    a ceramic substrate;
    a resistor element formed on said ceramic substrate in a desired pattern, for generating heat upon power supply;
    terminal portions formed on both ends of said resistor element; and
    an insulating layer covering the surface of said resistor element.

2. The thermal cutting blade according to claim 1, wherein said insulating layer is formed of an inorganic insulating material.

3. The thermal cutting blade according to claim 2, wherein said resistor element is formed by printing a conductive paste in a desired pattern and baking it, and at least said resistor element and said insulating layer are formed by simultaneous baking.

4. The thermal cutting blade according to claim 2, wherein said resistor element is formed by printing a conductive paste in a desired pattern and baking it, and said resistor element and said insulating layer are formed in individual baking steps separately in the sequential order mentioned.

5. A thermal cutting blade of a self-heating type for melting and cutting a resin tube, comprising

a metal substrate;
a first insulating layer made of an inorganic insulating material and formed on said metal substrate;
a resistor element formed on said first insulating layer in a desired pattern, for generating heat upon power supply;
terminal portions formed on both ends of said resistor element; and
a second insulating layer covering the surface of said resistor element.

6. The thermal cutting blade according to claim 5, wherein said second insulating layer is formed of an inorganic insulating material.

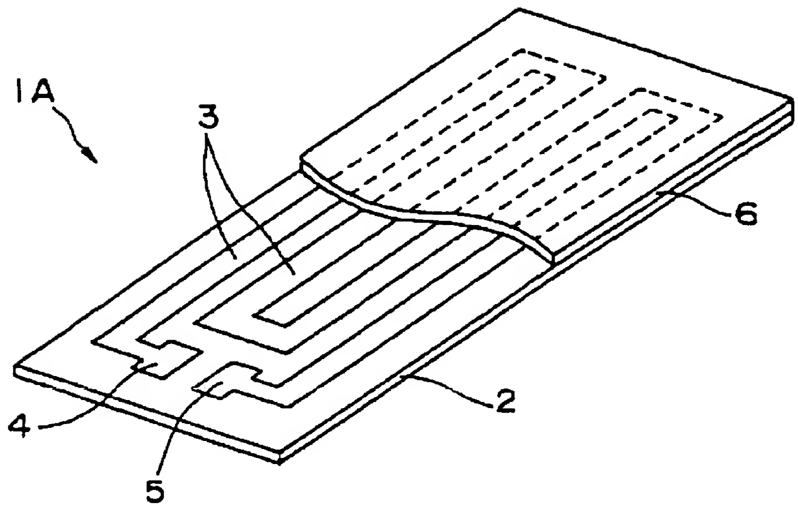
7. The thermal cutting blade according to claims 5 or 6, wherein said resistor element is formed by printing a conductive paste in a desired pattern and baking it, and at least said first insulating layer and said resistor element are formed by simultaneous baking.

8. The thermal cutting blade according to claims 5 or 6, wherein said resistor element is formed by printing a conductive paste in a desired pattern and baking it, and said first insulating layer, said resistor element, and said second insulating layer are formed by simultaneous baking.

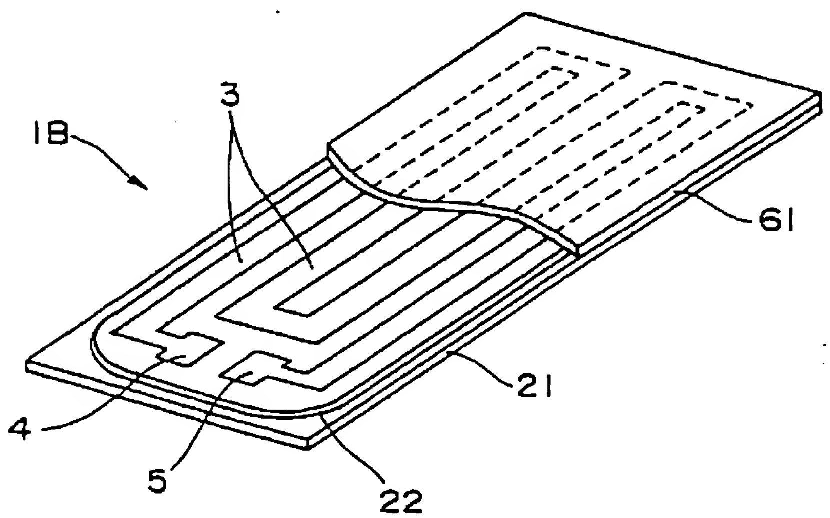
9. The thermal cutting blade according to claims 5 or 6, wherein said resistor element is formed by printing a conductive paste in a desired pattern and baking it, and said first insulating layer and said resistor element are formed in individual baking steps, separately in the order mentioned.

10. The thermal cutting blade according to claims 5 or 6, wherein said resistor element is formed by printing a conductive paste in a desired pattern and baking it, and said first insulating layer, said resistor element and said second insulating element are formed in individual baking steps, separately in the order mentioned.

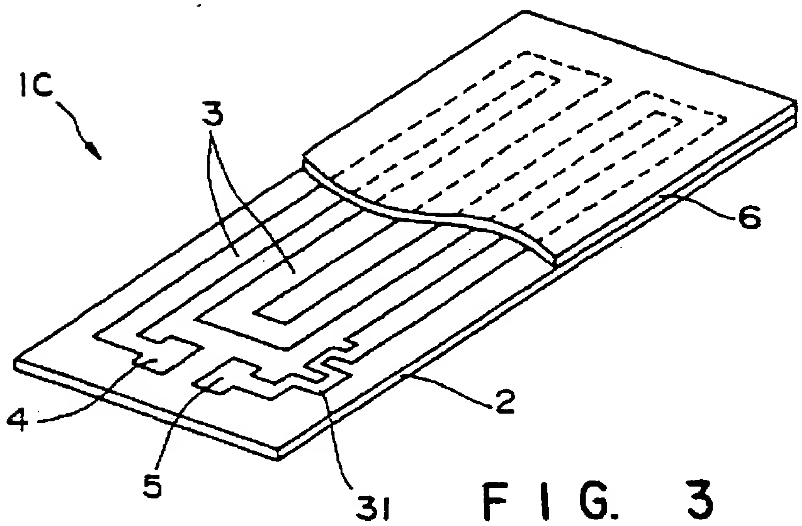
11. The thermal cutting blade according to any one of claims 1 to 10, wherein a high temperature fuse portion which is melted and cut off if a predetermined high temperature condition is maintained for a predetermined time period, is provided in at least one portion of said resistor element.



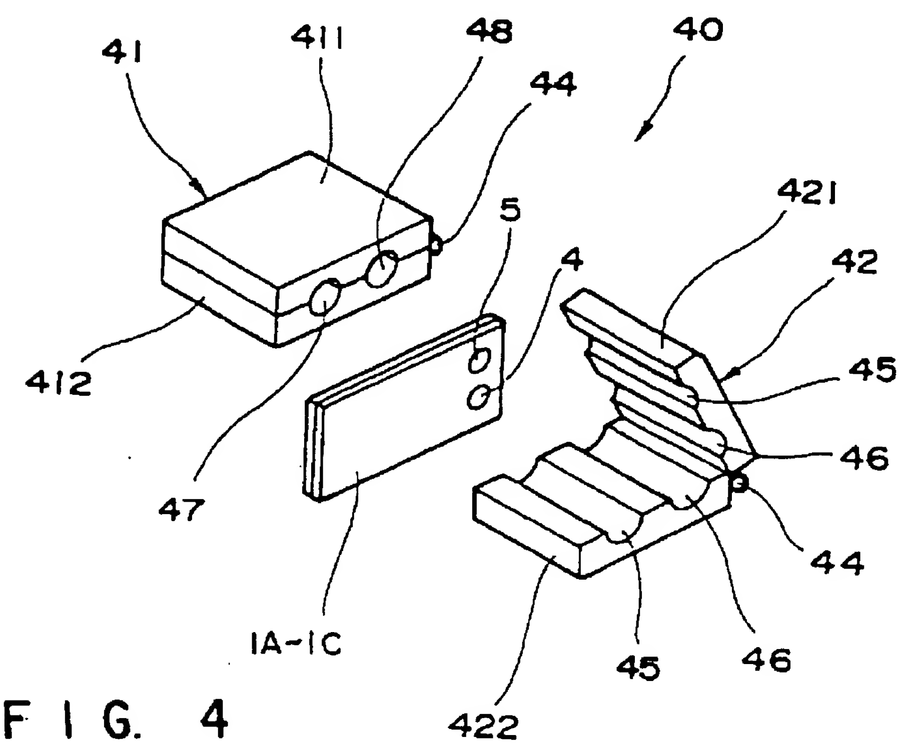
F I G. 1



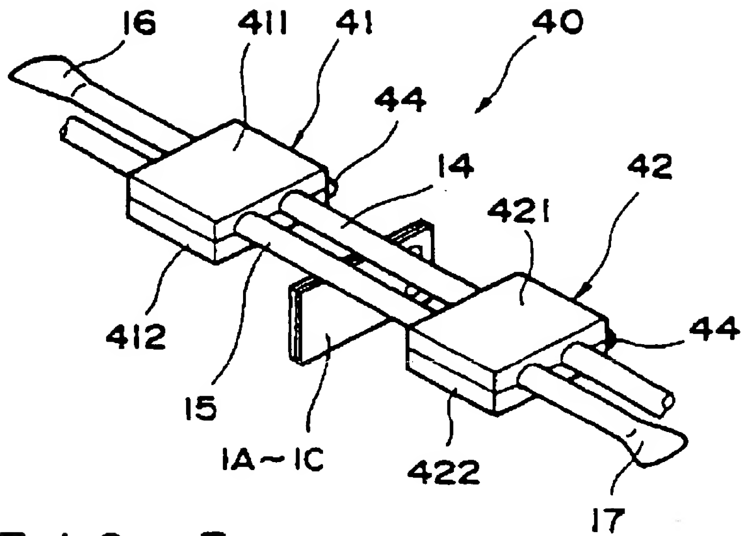
F I G. 2



F I G. 3



F I G. 4


16
411
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1A~1C
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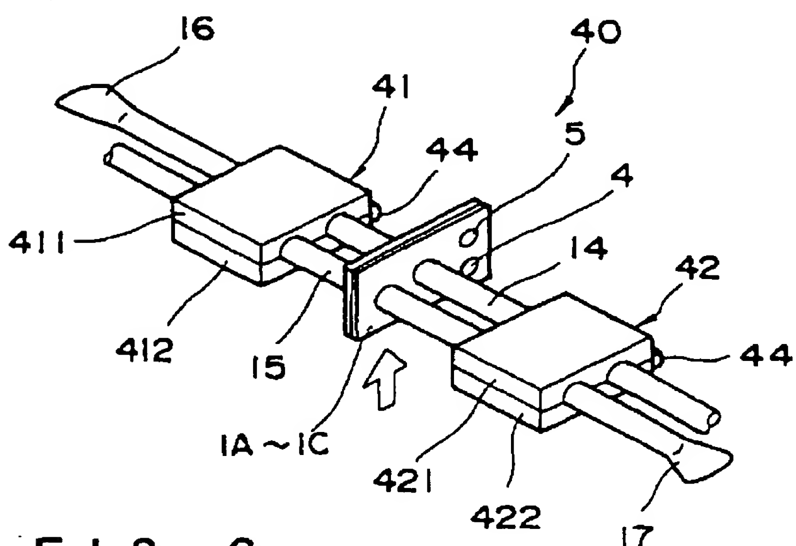
F I G. 5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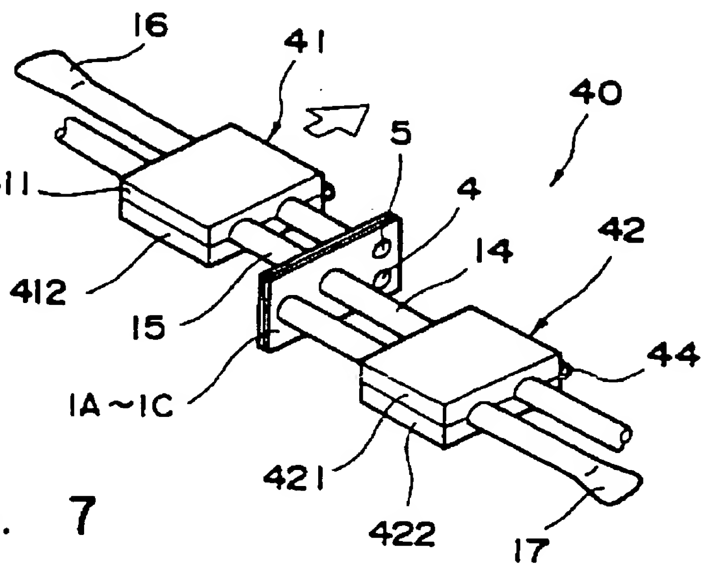
F I G. 6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1A~1C
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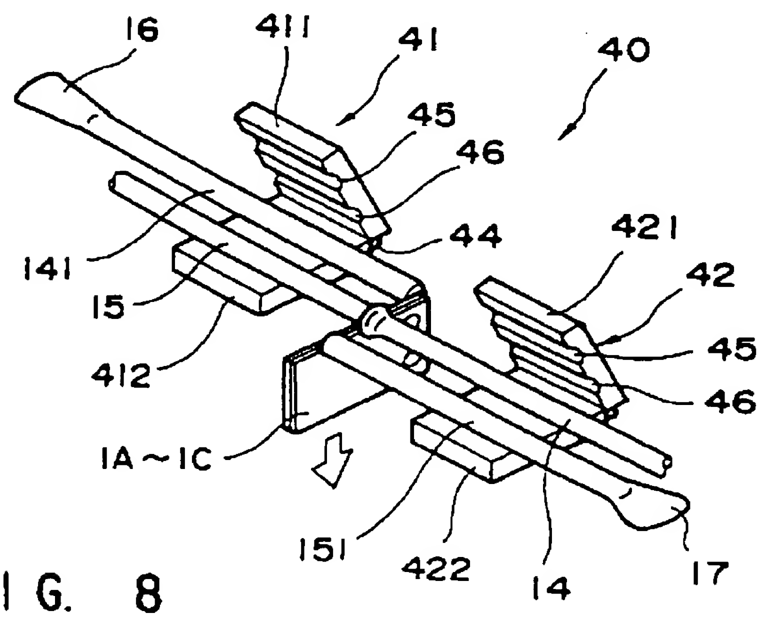
FIG. 7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141
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412
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1A~1C
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14
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FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP96/00488

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 B26F3/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 B26F3/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1925 - 1996
Kokai Jitsuyo Shinan Koho	1971 - 1996
Toroku Jitsuyo Shinan Koho	1994 - 1996

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No. 200725/1983 (Laid-open No. 109796/1985)(Stanley Electric Co., Ltd.), July 25, 1985 (25. 07. 85), Claim (Family: none)	1 - 10
Y	JP, 59-49925, A (E. I. Du Pont de Nemours and Co.), March 22, 1984 (22. 03. 84) Line 7, upper left column to line 19, upper right column, page 3 & EP, 103977, A1 & US, 4501951, A & CA, 1205146, A1	1 - 10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
March 14, 1996 (14. 03. 96)	April 2, 1996 (02. 04. 96)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

文献3

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特開平8－243991

(43)公開日　平成８年(1996) ９月24日

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H05B 3/20	328		H05B 3/20 328	
	393		393	

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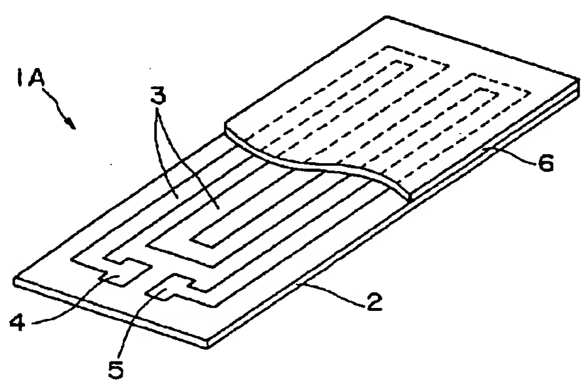
最終頁に続く

(54)【発明の名称】　加熱切断刃

(57)【要約】

【構成】本発明の加熱切断刃１Ａは、樹脂製チューブを溶融、切断するために用いられる自己発熱型の加熱切断刃であり、セラミックス製基板２を有し、その上に所望パターンの通電により発熱する抵抗体３が形成されている。この抵抗体３の両端部には、それぞれ、端子部４、５が形成されている。抵抗体３上には、好ましくは無機系材料で構成される絶縁層６が、端子４、５の部分を除き抵抗体３の表面を被覆するように形成されている。抵抗体３および端子４、５は、例えば、スクリーン印刷法により導電性ペーストを所望パターンに印刷、形成し、これを絶縁層６とともに低温同時焼成することにより形成される。

【効果】熱特性に優れるとともに、簡易な構成で厚さが薄く、また製造が容易で、コストが安価な加熱切断刃が提供される。



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【特許請求の範囲】
【請求項１】　樹脂製チューブを溶融、切断する自己発熱型の加熱切断刃であって、
セラミックス製基板と、該セラミックス製基板上に所望のパターンで形成され、通電により発熱する抵抗体と、該抵抗体の両端部に形成された端子部と、前記抵抗体の表面を被覆する絶縁層とで構成されることを特徴とする加熱切断刃。
【請求項２】　前記絶縁層は、無機絶縁材料で構成されている請求項１に記載の加熱切断刃。
【請求項３】　前記抵抗体は、導電性ペーストを所望のパターンに印刷形成し、これを焼成して得られるものであり、少なくとも前記抵抗体と前記絶縁層とが、同時焼成により形成される請求項２に記載の加熱切断刃。
【請求項４】　樹脂製チューブを溶融、切断する自己発熱型の加熱切断刃であって、
金属製基板と、該金属製基板上に形成された無機絶縁材料で構成される第１の絶縁層と、該第１の絶縁層上に所望のパターンで形成された抵抗体と、該抵抗体の両端部に形成された端子部と、前記抵抗体の表面を被覆する第２の絶縁層とで構成されることを特徴とする加熱切断刃。
【請求項５】　前記第２の絶縁層は、無機絶縁材料で構成されている請求項４に記載の加熱切断刃。
【請求項６】　前記抵抗体は、導電性ペーストを所望のパターンに印刷形成し、これを焼成して得られるものであり、少なくとも前記第１の絶縁層と前記抵抗体とが、同時焼成により形成される請求項４または５に記載の加熱切断刃。
【請求項７】　前記抵抗体は、導電性ペーストを所望のパターンに印刷形成し、これを焼成して得られるものであり、前記第１の絶縁層と前記抵抗体と前記第２の絶縁層とが、同時焼成により形成される請求項４または５に記載の加熱切断刃。
【請求項８】　前記抵抗体の少なくとも一部に、所定の高温状態が所定時間継続すると溶断する昇温溶断部を有している請求項１ないし７のいずれかに記載の加熱切断刃。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、樹脂製チューブを溶融、切断するのに用いられる自己発熱型の加熱切断刃に関するものである。
【０００２】
【従来の技術】可撓性を有する樹脂製チューブ同士を溶融、切断してこれらを無菌的に接続するチューブ接続装置が知られている（特公昭６１－３０５８２号公報）。
【０００３】このチューブ接続装置は、接続すべき２本のチューブを平行に保持し得る一対のホルダー（ブロック）と、両ホルダー間に設置され、チューブを横切るように移動可能に設置されたウエハー（板状の加熱切断刃）とを備え、両ホルダーに２本のチューブを平行にかつ反対方向に保持した状態で、ウエハーを加熱するとともに移動して２本のチューブを溶融・切断し、次いで、一方のホルダーをチューブが並べられた方向に移動して、接続するチューブの切り口同士を一致させるとともにウエハーを除去し、両チューブを融着、接続するものである。

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【０００４】このチューブ接続装置に用いられるウエハーは、金属板を２つ折りにし、その内面に絶縁層（接着剤層）を介して所望のパターンの抵抗体が形成されており、該抵抗体の両端にそれぞれ形成された端子部を介して抵抗体に通電することにより抵抗体が発熱し、ウエハー全体が加熱されるようになっている（特開昭５９－４９９２５号公報）。
【０００５】しかしながら、このウエハーは、金属板／絶縁層／抵抗体／絶縁層／金属板の５層を積層したものであり、その構造が複雑であるとともに、ウエハーの厚さが厚くなり、チューブの溶融切断、融着接続に不利であり、チューブ接続部の歩留りが悪いという欠点がある。また、ウエハーの製造に関しても、絶縁層の形成、抵抗体の形成、金属板の折り曲げ等の工程を必要とし、製造工程が多く、製造コスト、材料コストが高いという欠点がある。
【０００６】
【発明が解決しようとする課題】本発明の目的は、簡易な構成で、厚さが薄く、また製造コストが安価な加熱切断刃を提供することにある。
【０００７】
【課題を解決するための手段】このような目的は、下記（１）～（８）の本発明により達成される。
【０００８】（１）　樹脂製チューブを溶融、切断する自己発熱型の加熱切断刃であって、セラミックス製基板と、該セラミックス製基板上に所望のパターンで形成され、通電により発熱する抵抗体と、該抵抗体の両端部に形成された端子部と、前記抵抗体の表面を被覆する絶縁層とで構成されることを特徴とする加熱切断刃。
【０００９】（２）　前記絶縁層は、無機絶縁材料で構成されている上記（１）に記載の加熱切断刃。
【００１０】（３）　前記抵抗体は、導電性ペーストを所望のパターンに印刷形成し、これを焼成して得られるものであり、少なくとも前記抵抗体と前記絶縁層とが、同時焼成により形成される上記（２）に記載の加熱切断刃。
【００１１】（４）　樹脂製チューブを溶融、切断する自己発熱型の加熱切断刃であって、金属製基板と、該金属製基板上に形成された無機絶縁材料で構成される第１の絶縁層と、該第１の絶縁層上に所望のパターンで形成された抵抗体と、該抵抗体の両端部に形成された端子部と、前記抵抗体の表面を被覆する第２の絶縁層とで構成

されることを特徴とする加熱切断刃。

【0012】(5)　前記第2の絶縁層は、無機絶縁材料で構成されている上記(4)に記載の加熱切断刃。

【0013】(6)　前記抵抗体は、導電性ペーストを所望のパターンに印刷形成し、これを焼成して得られるものであり、少なくとも前記第1の絶縁層と前記抵抗体とが、同時焼成により形成される上記(4)または(5)に記載の加熱切断刃。

【0014】(7)　前記抵抗体は、導電性ペーストを所望のパターンに印刷形成し、これを焼成して得られるものであり、前記第1の絶縁層と前記抵抗体と前記第2の絶縁層とが、同時焼成により形成される上記(4)または(5)に記載の加熱切断刃。

【0015】(8)　前記抵抗体の少なくとも一部に、所定の高温状態が所定時間継続すると溶断する昇温溶断部を有している上記(1)ないし(7)のいずれかに記載の加熱切断刃。

【0016】

【実施例】以下、本発明の加熱切断刃を添付図面に示す好適実施例に基づいて詳細に説明する。

【0017】図1は、本発明の加熱切断刃の実施例を示す斜視図である。同図に示すように、本発明の加熱切断刃1Aは、セラミックス製基板2を有している。セラミックス製基板2を構成するセラミックス材料としては、酸化物系セラミックス、非酸化物系セラミックスのいずれでもよく、例えば、アルミナ(Al_2O_3)、シリカ(SiO_2)、ベリリア(BeO)、炭化ケイ素(SiC)、窒化アルミ(AlN)、窒化ホウ素(BN)、窒化ケイ素(Si_3N_4)のうちの1種または2種以上を組み合わせたもの(例えば、サイアロン)、さらには、これらに例えばSiO_2、B_2O_3、PbO、ZnO_2、MgO、CaO、BaO、SrO、Y_2O_3等のうちの1種以上が添加されたものが挙げられる。

【0018】このセラミックス製基板2は、十分な剛性を有し、また、それ自体絶縁性を有するので、後述する抵抗体3の絶縁層としても機能する。セラミックス製基板2の厚さは、特に限定されないが、チューブの切断に耐え得る十分な強度を有するものであればよい。

【0019】セラミックス製基板2上には、所望のパターンの抵抗体3が形成されている。この抵抗体3の両端部には、それぞれ、端子4、5が形成されている。端子4、5の材料としては抵抗体3と同一でもよい。このような抵抗体3および端子4、5(以下、これらを総称して抵抗体3等という)は、例えば、後述するようなスクリーン印刷法、転写法、エッチング、メッキ、蒸着、スパッタリング、CVD等の方法により好ましくは一括して形成される。

【0020】抵抗体3を構成する金属材料としては、例えば、AgまたはAg－Pd合金、Ag－Pt合金、Ag－Pd－Pt合金等のAg系合金、AuまたはAu－

Cu合金等のAu系合金、NiまたはNi－Cr合金等のNi系合金、ステンレス鋼等のFe系合金、CuまたはCu－Zn合金、Cu－Sn合金等のCu系合金、AlまたはAl－Mg合金、Al－Cu合金等のAl系合金等が挙げられる。抵抗体3を印刷形成する場合は、AgまたはAg系合金をガラスで結合した通称、厚膜導電または抵抗ペーストを主として用いるのが好ましい。

【0021】抵抗体3等の膜厚(硬化状態での膜厚)は、特に限定されないが、好ましくは10～25μm程度、より好ましくは10～15μm程度とされる。抵抗体3の抵抗値は、好ましくは5～50Ω程度、より好ましくは5～20Ω程度とされる。

【0022】抵抗体3上には、絶縁層6が、端子4、5の部分を除き抵抗体3の表面を被覆するように形成されている。この絶縁層6は、例えば、前述したような各種セラミックスまたはそれを形成する材料や、例えばホウケイ酸鉛ガラス、鉛ガラス、リン酸塩ガラスのような各種ガラス等の無機材料、またはポリイミド等の耐熱性を有する有機材料よりなる被膜で構成することができるが、特に前記セラミックス、ガラス等の無機絶縁材料で構成するのが好ましい。なお、このセラミックスとしては、前記セラミックス製基板2で挙げたものと同様のものが挙げられる。

【0023】絶縁層6の膜厚(硬化状態での膜厚)は、特に限定されないが、好ましくは1～100μm程度、より好ましくは5～50μm程度とされる。

【0024】加熱切断刃1Aの厚さは、特に限定されないが、0.1～2.5mm程度が好ましく、0.1～1.3mm程度がより好ましく、0.2～0.5mm程度がさらに好ましい。加熱切断刃1Aの厚さが薄過ぎると、割れ、欠け等の破損が生じ易く、取り扱いが不便となり、また、厚さが厚過ぎると、チューブの溶融切断後、接続する際に支障が生じることがあり、接合強度の低下を招く。

【0025】加熱切断刃1Aの厚さをより薄くできることは、チューブの切断、接続において有利であるとともに、複数の加熱切断刃1Aを重ねた状態で、図示しないカートリッジ(ケース)に収納する場合に、一定容量のカートリッジ内により多くの枚数の加熱切断刃1Aを収納することができるという点でも有利である。

【0026】以上のような加熱切断刃1Aでは、表面がセラミックスで構成されているため、優れた熱伝達性および耐熱性を有し、非常に安定な熱特性を確保することができる。

【0027】次に、加熱切断刃1Aの製造方法について、抵抗体3等をスクリーン印刷法により形成し、抵抗体3と絶縁層6とを同時焼成により形成する場合を例にして説明する。

【0028】[1A]　予め製造されたセラミックス製基板2(未切断状態の大型の原板)上に、抵抗体3等を

形成するための導電性ペーストをスクリーン印刷法により所望のパターンに印刷、形成する。

【００２９】導電性ペーストの主成分である導電性物質は、通常、各種金属粒子または金属化合物粒子であり、そのなかでも、特にＡｇまたはＡｇを主成分とするＡｇ系合金であるのが好ましい。Ａｇ系合金としては、Ａｇ－Ｐｄ合金、Ａｇ－Ｐｔ合金、Ａｇ－Ｐｄ－Ｐｔ合金等が挙げられる。Ｐｄを含むＡｇ系合金は、純Ａｇに比べ耐マイグレーション性に優れる。このようなＡｇまたはＡｇ系合金は、通常、導電性ペースト中に粒子として存在する。このＡｇまたはＡｇ系合金の粒子の平均粒径は、０．５～５０μm 程度、特に１～２０μm 程度とするのが好ましい。平均粒径が０．５μm 未満であると抵抗体３等の収縮率が大きくなり、また、５０μm を超えると導電性ペーストの印刷性、分散性が低下することがある。

【００３０】導電性物質は、前記ＡｇまたはＡｇ系合金に代わり、またはこれに加え、例えばＣｕ、Ａｕまたはこれらを含む合金を用いることもできる。また、導電性物質には、二酸化ルテニウム、ルテニウム酸鉛等の導電複合酸化物を含んでいてもよい。

【００３１】導電性ペーストのビヒクルとしては、エポキシ樹脂、熱硬化性メラミン樹脂、アクリル系樹脂、ニトロセルロース、エチルセルロース、フェノール樹脂、ビニル樹脂等のバインダーや、アルコール、トルエン、キシレン、ブチルカルビトール、テルピネオール等の溶剤、ポリ塩化ビニルのような可塑性向上のための熱可塑性樹脂、その他分散剤、活性剤、粘度調整剤、膜密着力促進物質（例えば、金属酸化物）、抵抗調整物質等が挙げられ、これらのうちの任意のものを目的に応じて適宜配合することができる。

【００３２】また、特に、上述したような導電性ペーストの場合、スクリーン印刷におけるスクリーンは、１８０～３００メッシュ、特に２００～２５０メッシュのものを用いるのが好ましい。

【００３３】前述した抵抗体３等の膜厚は、スクリーン印刷における条件、すなわち、スクリーン乳剤厚、スキージーのラバー硬度、スクリーンと被印刷体との間隔、スキージーの移動速度等の条件を適宜調整することで容易に設定することができる。なお、本発明では、抵抗体３、端子４、５のそれぞれにおいて、導電性ペーストの組成、粘度、膜厚等の条件が異なっていてもよい。

【００３４】［２Ａ］　アルミナ粉末のような絶縁層６の原材料に、バインダー、溶剤等を加え、これらを混練してスラリー化する。用いるアルミナ粉末の平均粒径は、０．１～１００μm 程度、特に０．１～１０μm 程度とするのが好ましい。

【００３５】次に、端子４、５の部分を必要に応じて所望の形状（例えば円形）にマスキングした状態で、前記スラリーを塗布、乾燥する。塗布の方法としては、例えば、スクリーン印刷、スプレー、ディッピング、ロールコーティング等が挙げられる。

【００３６】なお、絶縁層６は、前記塗布法により形成する場合に限らず、その原材料となるグリーンシートを例えばドクターブレード法により作製し、該グリーンシートを積層する方法により形成してもよい。

【００３７】［３Ａ］　セラミックス製基板２上に形成された抵抗体３の導電性ペーストおよび絶縁層６の塗膜を、例えば炉を用いて低温同時焼成する。この焼成の好適な条件は、好ましくは５００～９５０℃程度の温度で、５～３０分程度である。なお、焼成前に、必要に応じ、熱プレス、脱バインダー処理、切断用溝の形成等を行ってもよい。

【００３８】［４Ａ］　以上のようにして製造された大型の原板を所望に切断（分割）して、複数の加熱切断刃１Ａを得る。上述したようなスクリーン印刷法により抵抗体３等を製造した場合には、複雑で微細なパターン形状であっても容易かつ短時間に製造することができ、製造コストも安価である。しかも、抵抗体３のパターンの寸法精度が向上するため、安定した抵抗値を得ることができる。すなわち、抵抗体３の設計抵抗値に対する誤差を±５％以内、特に±１．５％以内とすることができる。

【００３９】また、抵抗体３等のセラミックス製基板２に対する密着性が極めて高いので、製造中等に抵抗体３等が剥離し、リークが生じたりすることはない。また、抵抗体３の導電性ペーストと、絶縁層６の塗膜とを同時焼成するので、製造工程が簡素化され、製造コストが低減する。

【００４０】なお、完成した（予め焼成された）セラミックス製基板２を用いず、セラミックス製基板２の基板材料となるグリーンシートを例えばドクターブレード法により作製し、このグリーンシート上に導電性ペーストによる抵抗体パターン、および絶縁層塗膜を順次形成し、これら全てを一括で同時焼成してもよい。また、逆に、各層をそれぞれ別個に焼成してもよい。

【００４１】また、本発明においては、抵抗体３の形成方法は、上記のようなスクリーン印刷法に限らず、例えば、ステンレス箔、ニッケルクロム箔等の金属箔を打抜き、エッチング等により所望のパターンに形成したり、メッキ、蒸着、スパッタリング、ＣＶＤ等により抵抗体３を形成してもよい。

【００４２】図２は、本発明の加熱切断刃の他の実施例を示す斜視図である。同図に示す加熱切断刃１Ｂは、金属製基板２１を有している。この金属製基板２１は、基板表面に沿って均一に熱を拡散、分布させることができるような熱伝導性に優れる金属で構成されている。具体的には、例えば、銅、アルミニウム、金、銀、鉄、ニッケル、コバルト、チタンまたはこれらの金属を含む合金（例えば、ステンレス鋼、真鍮、銅－ベリリウム合金、

アルミニウム合金、チタン合金）が挙げられるが、このなかでも、銅または銅合金（特に銅を９９．９wt%以上含有する銅合金）が好ましい。

【００４３】また、金属製基板２１の好適な厚さは、その構成材料にもよるが、通常、０．０５～２．５mm程度が好ましく、０．１～０．５mm程度がより好ましい。

【００４４】なお、第１の絶縁層２２の接着強度を高めるために、金属製基板２１の第１の絶縁層２２を形成する面を粗面とすることができ、そのために、例えば、粗面ロールによる圧延、サンドブラスト、ジェットスクライブ等の金属製基板２１の表面に粗面加工を施す方法が挙げられる。

【００４５】金属製基板２１上には、第１の絶縁層２２が形成されている。この第１の絶縁層２２は、前記絶縁層６と同様の構成、すなわち、前述したような各種無機絶縁材料よりなるものであるのが好ましい。

【００４６】第１の絶縁層２２の膜厚（硬化状態での膜厚）は、特に限定されないが、好ましくは３～１００μm 程度、より好ましくは５～５０μm 程度とされる。第１の絶縁層２２上には、前記同様の抵抗体３および端子４、５が同様の方法で形成されている。さらに、抵抗体３上には、前記絶縁層６と同様の第２の絶縁層６１が、端子４、５の部分を除き抵抗体３の表面を被覆するように形成されている。

【００４７】加熱切断刃１Ｂについても、前述したような効果が得られ、さらに、強度の高い金属製基板２１を有するため、割れ、欠け、クラックの発生等が防止され、加熱切断刃１Ｂの厚さをより薄くすることができる。

【００４８】次に、加熱切断刃１Ｂの製造方法について、抵抗体３等をスクリーン印刷法により形成し、第１の絶縁層２２、抵抗体３および第２の絶縁層６１を同時焼成により形成する場合を例にして説明する。

【００４９】［１Ｂ］　金属製基板２１（未切断状態の大型の原板）上に、第１の絶縁層２２の塗膜を形成する。すなわち、前記工程［２Ａ］と同様に、アルミナ粉末のような第１の絶縁層２２の原材料に、バインダー、溶剤等を加え、これらを混練してスラリー化し、次いで、このスラリーを金属製基板２１の表面に塗布、乾燥する。

【００５０】［２Ｂ］　前記工程［１Ａ］と同様にして、抵抗体３等を形成するための導電性ペーストをスクリーン印刷法により所望のパターンに印刷、形成する。

【００５１】［３Ｂ］　前記［１Ｂ］と同様にして、抵抗体３上に第２の絶縁層６１の塗膜を形成する。

【００５２】［４Ｂ］　金属製基板２１上に形成された第１の絶縁層２２の塗膜、抵抗体３の導電性ペーストおよび第２の絶縁層６１の塗膜を、例えば炉を用いて低温同時焼成する。この焼成の好適な条件や前処理は、前記工程［３Ａ］と同様である。

【００５３】［５Ｂ］　以上のようにして製造された原板を所望に切断（分割）して、複数の加熱切断刃１Ｂを得る。

【００５４】なお、第１の絶縁層２２および第２の絶縁層６１の形成には、それぞれ前記と同様、グリーンシートを用いてもよい。また、同時焼成は、第１の絶縁層２２の塗膜および抵抗体３の導電性ペーストに対してのみ行ってもよい。さらには、各層をそれぞれ別個に焼成してもよい。

【００５５】図３は、本発明の加熱切断刃の他の実施例を示す斜視図である。同図に示す加熱切断刃１Ｃは、抵抗体３の一部に、昇温溶断部３１が形成されている以外は、前記加熱切断刃１Ａと同様である。

【００５６】昇温溶断部（ヒューズ）３１は、所定の高温状態が所定時間継続すると溶断する材料で構成されている。この材料としては、例えば、錫－鉛合金に代表される低融点合金が挙げられる。

【００５７】昇温溶断部３１が溶断する温度および時間は、チューブの溶融温度より低い温度で、かつチューブの切断、接続に要する時間と同等またはそれより短い時間とされ、例えば、約３２０℃で約１０秒とされる。

【００５８】本発明の加熱切断刃は、基本的には、１回毎に使い捨て（シングルユース）されるものであるが、加熱切断刃１Ｃでは、端子４、５間の導通、非導通により、それが未使用か使用済みかを判別することができる。すなわち、端子４、５間に通電され、抵抗体３が発熱してチューブ溶融温度以上に昇温し、所定時間経過すると、昇温溶断部３１が溶断するので、次回に端子４、５間に通電しても、抵抗体３は発熱せず、使用済みであることがわかる。従って、複数回の使用を未然に防止することができる。

【００５９】なお、加熱切断刃１Ｃは、抵抗体３の一部を昇温溶断部３１としたものであるが、これに代えて、抵抗体３の全体を、前記所定の高温度状態が所定時間継続すると溶断する材料で構成してもよい。この場合、端子４、５間への通電時に温度が最も高くなる抵抗体３の中央部分が昇温溶断部となり、この昇温溶断部が１回の使用で溶断し、２回目以後の使用を未然に防止する。

【００６０】また、昇温溶断部は、抵抗体３の全部または一部を迂回してバイパス接続されたもの（図示せず）でもよい。この場合、加熱切断刃の１回目の使用では、端子４、５間へ通電すると、抵抗体３の全部または一部を迂回して昇温溶断部に電流が流れ、昇温溶断部が発熱して溶断し、その後抵抗体３の全体に電流が流れて発熱する。加熱切断刃の２回目以後の使用では、端子４、５間へ通電すると、昇温溶断部は既に溶断しているため、抵抗体３の全体に電流が流れて発熱する。これらの電圧の上昇パターンの相違を検出することにより、加熱切断刃が未使用か使用済みかを判別することができる。

【００６１】以上のような加熱切断刃１Ｃは、前記工程

［１Ａ］～［４Ａ］と同様にして製造することができる。この場合、工程［１Ａ］において、抵抗体３用の導電性ペーストと、昇温溶断部３１用の導電性ペーストとを、それぞれ２度のスクリーン印刷により所望のパターンに形成することができる。また、昇温溶断部３１の形成は、抵抗体３用の導電性ペーストの焼成後に行うことができる。なお、前述したような昇温溶断部は、前記加熱切断刃１Ｂに対しても設置することができ、同様の効果が得られる。

【００６２】次に、本発明の加熱切断刃１Ａ～１Ｃを用いたチューブ接続方法の一例について説明する。加熱切断刃１Ａ～１Ｃ（以下、加熱切断刃１Ａで代表する）は、所定のチューブ接続装置に装填されて使用される。

【００６３】図４は、チューブ接続装置４０の構成例を示す斜視図、図５～図８は、それぞれ、チューブ接続装置４０によるチューブ１４および１５の接続工程を示す斜視図である。これらの図に示すように、チューブ接続装置４０は、一対のホルダー４１、４２の間に本発明の加熱切断刃１Ａを交換可能に配置した構造であり、ホルダー４１、４２の間に、例えばポリ塩化ビニル製の２本のチューブ１４、１５を並べて架設し、加熱された加熱切断刃１Ａにてこれらを溶融、切断し、片方のホルダー４１を移動させて接続するチューブの切り口同士を一致させ、その後、加熱切断刃１Ａを取り除いてチューブ１４および１５を融着するものである。

【００６４】さらに詳述すると、ホルダー４１および４２は、それぞれ図４中上下に分割されたホルダー片４１１、４１２および４２１、４２２から構成されており、これらのホルダー片４１１、４１２および４２１、４２２は、それぞれ、支点４４により回動可能となっている。

【００６５】また、各ホルダー片４１１、４１２および４２１、４２２の対向面（内面）には、断面形状が半円形の溝４５、４６がそれぞれ２つ平行に形成され、ホルダー片４１１、４１２および４２１、４２２を重ね合わせた状態で、円形断面のチューブ保持部４７、４８が形成されるようになっている。

【００６６】なお、図示されていないが、ホルダー４１および４２の加熱切断刃１Ａ側の端部には、それぞれ、ホルダー片４１１、４１２および４２１、４２２を閉じたときにチューブ１４および１５を挟持して扁平とし、その内部を閉塞するようなチューブ挟持部が設けられていてもよい。

【００６７】次に、チューブ接続装置４０によるチューブ接続方法について説明する。図５に示すように、チューブ１４および１５を、それらの閉塞端１６および１７が相互に逆方向に向くように一定長さ平行に重ねて、２つのホルダー４１、４２の溝４５、４６内に設置し、ホルダー片４１１、４１２および４２１、４２２を閉じて、２本のチューブ１４および１５をチューブ保持部４７、４８に挟持、固定する。一方、前記カートリッジより１枚の加熱切断刃１Ａを取り出して、ホルダー４１、４２の間隙の下方にある切断刃支持部（図示せず）にセットする。

【００６８】次に、通電手段（図示せず）により、加熱切断刃１Ａの端子４、５間に例えば１５～２４Ｖの電圧を印加して加熱切断刃１Ａ内の抵抗体３に通電する。これにより、抵抗体３が発熱し、加熱切断刃１Ａは、チューブ１４および１５の溶融温度以上の温度（例えば２６０～３３０℃程度）に加熱される。

【００６９】この状態で、図６に示すように、加熱切断刃１Ａを図中上方に移動すると、加熱切断刃１Ａの熱によってチューブ１４および１５は溶融、切断される。このとき、チューブ１４および１５の切断端部は、溶融または軟化した状態で高温であり、かつ外部と連通しないため、無菌状態が維持される。

【００７０】次に、図７に示すように、チューブ１４および１５の切断端部の溶融状態を維持しつつ、一方のホルダー４１をチューブ１４、１５の配列方向に移動し、切断されたチューブ１４および１５の切り口同士が一致する位置で停止、固定する。

【００７１】次に、図８に示すように、加熱切断刃１Ａを図中下方に引き抜き、一方のホルダー４２を他方のホルダー４１に接近するようチューブ１４、１５の長手方向に微小距離移動する。これにより、溶融したチューブ１４および１５の切り口同士が融着され、両チューブ１４および１５の接続がなされる。

【００７２】このような加熱切断刃１Ａによる両チューブ１４、１５の切断から接続までの一連の動作において、チューブ１４、１５の切り口およびその周辺部は、溶融または軟化した状態で高温であり、また、切り口同士が密着、接合されるまでは高温の加熱切断刃１Ａの表面に密着しており、外部と連通しないため、無菌状態がほぼ完全に維持される。チューブ１４および１５の接続後、切断された閉塞端１６、１７を含むチューブ片１４１および１５１は廃棄される。

【００７３】また、次回に他のチューブの接続を行う際には、使用済の加熱切断刃１Ａを新たな加熱切断刃１Ａに交換し、使用済の加熱切断刃１Ａは廃棄される。加熱切断刃１Ｃの場合には、前述したように、使用済みか否かを知ることができ、使用済みの加熱切断刃１Ｃを再使用することが防止される。以上、本発明の加熱切断刃を図示の実施例に基づいて説明したが、本発明はこれらに限定されるものではない。

【００７４】

【発明の効果】本発明の加熱切断刃によれば、基板またはその抵抗体形成面に無機系の絶縁材料を用いたため、熱伝達性および耐熱性に優れ、熱容量も大きく、しかも、構造が簡易であり、すなわち積層数が少なく、加熱切断刃の厚さを薄くすることができる。従って、チュー

ブの溶融、切断、さらにはその融着接続を極めて良好に行うことができ、チューブ接続部の接合強度、気密性、無菌保持性も高い。特に、セラミックス製基板を用いた場合には、材料コストが低減され、金属製基板を用いた場合には、加熱切断刃の厚さをより薄くすることができる。

【0075】また、本発明の加熱切断刃は、製造が容易であり、特に、抵抗体を所望のパターンに印刷形成し、これを絶縁層等と同時焼成する場合には、製造工程が削減され、生産性が向上するとともに、大幅なコストダウンが図れる。

【0076】また、抵抗体の少なくとも一部に昇温溶断部を設けた場合には、加熱切断刃が使用済か否かの判定を行うことができ、使用済の加熱切断刃の再使用を未然に防止することができる。

【図面の簡単な説明】

【図１】本発明の加熱切断刃の実施例を示す斜視図である。

【図２】本発明の加熱切断刃の他の実施例を示す斜視図である。

【図３】本発明の加熱切断刃の他の実施例を示す斜視図である。

【図４】本発明の加熱切断刃を用いてチューブを切断、接続するチューブ接続装置の構成例を示す斜視図である。

【図５】図４に示すチューブ接続装置によるチューブの＊

＊接続工程を示す斜視図である。

【図６】図４に示すチューブ接続装置によるチューブの接続工程を示す斜視図である。

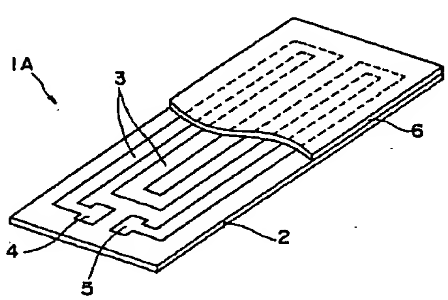
【図７】図４に示すチューブ接続装置によるチューブの接続工程を示す斜視図である。

【図８】図４に示すチューブ接続装置によるチューブの接続工程を示す斜視図である。

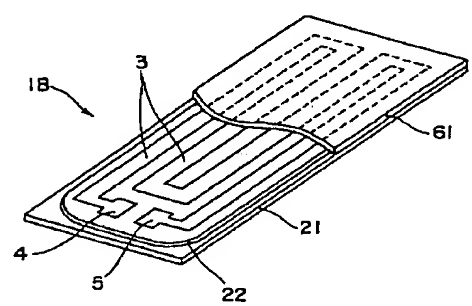
【符号の説明】

１Ａ～１Ｃ	加熱切断刃
２	セラミックス製基板
２１	金属製基板
２２	第１の絶縁層
３	抵抗体
４、５	端子
６	絶縁層
６１	第２の絶縁層
１４、１５	チューブ
１４１、１５１	チューブ片
１６、１７	閉塞端
４０	チューブ接続装置
４１、４２	ホルダー
４１１、４１２	ホルダー片
４２１、４２２	ホルダー片
４４	支点
４５、４６	溝
４７、４８	チューブ保持部

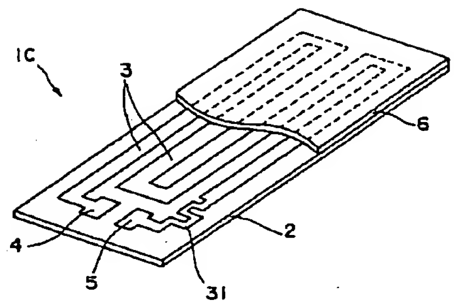
【図１】



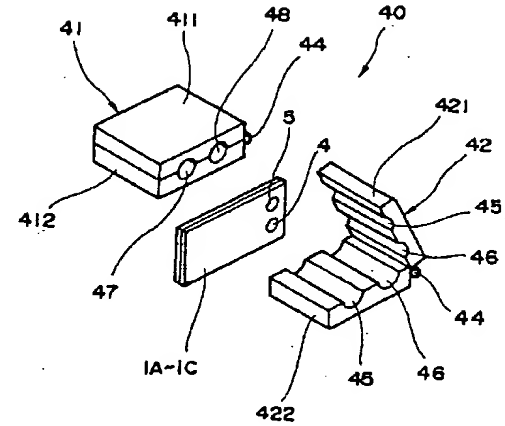
【図２】



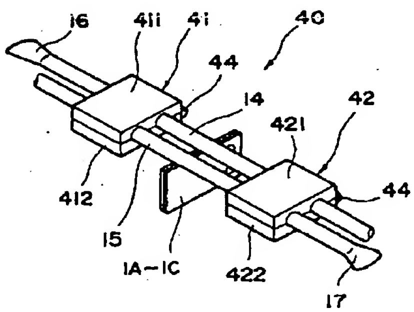
【図3】



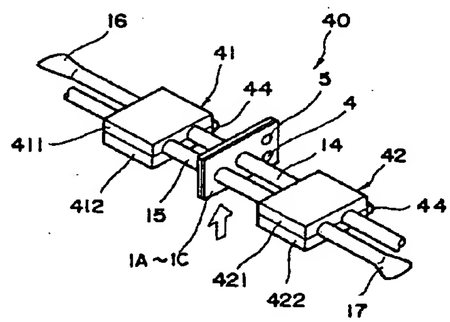
【図4】



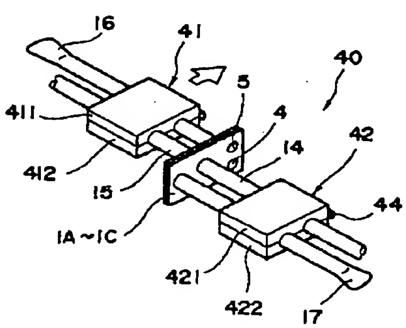
【図5】



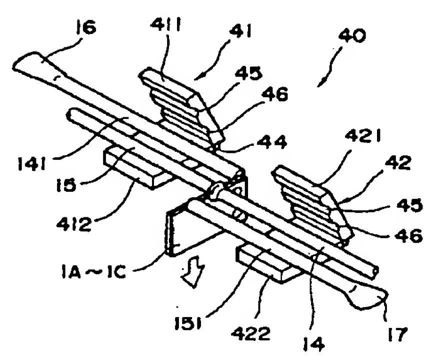
【図6】



【図7】



【図8】



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